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Evaluation of Imazosulfuron for Yellow Nutsedge (*Cyperus esculentus*) and Broadleaf Weed Control in Potato

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Field studies were conducted in 2007 and 2008 near Nyssa, OR, and Pasco and Paterson, WA to evaluate yellow nutsedge and broadleaf weed control and potato tolerance to imazosulfuron. No injury symptoms from imazosulfuron were evident on potato at Nyssa, whereas in Washington, imazosulfuron caused some chlorosis of potato foliage ranging from 6 to 15% and < 4% at 6 and 15 d after POST application, respectively. Sequential applications of imazosulfuron controlled yellow nutsedge better than a single PRE application. Sequential applications of imazosulfuron or imazosulfuron in combination with *s*-metolachlor controlled yellow nutsedge > 92 and 89% at 21 and 42 d after POST applications, respectively. Imazosulfuron controlled ≥ 98% of common lambsquarters and 100% of pigweed species. Imazosulfuron provided season-long control of common mallow at Nyssa. However, imazosulfuron failed to control Russian thistle at Paterson, and only partially controlled hairy nightshade. Yield of U.S. no. 1 potato at Nyssa ranged from 44 to 54 T ha^{-1} and 42 to 52 T ha^{-1} for imazosulfuron PRE and imazosulfuron sequential treatments in 2007 and 2008, respectively. U.S. no. 1 potato yield following imazosulfuron PRE and sequential treatments at Pasco ranged from 49 to 57 T ha^{-1} in 2007, and at Paterson from 36 to 54 T ha^{-1} in 2008. Lower yields in 2008 were attributed to poor control of hairy nightshade. Imazosulfuron has potential to become a valuable tool for yellow nutsedge management in potato. Studies are needed to evaluate the soil persistence for imazosulfuron in order to determine safety to crops grown in rotation with potato.
Nomenclature: Imazosulfuron; rimsulfuron; *s*-metolachlor; common lambsquarters, *Chenopodium album* L.; common mallow, *Malva neglecta* Wallr.; hairy nightshade, *Solanum physalifolium* Rusby; pigweed, *Amaranthus* spp.; Russian thistle *Salsola tragus* L.; yellow nutsedge, *Cyperus esculentus* L. CYPES; potato, *Solanum tuberosum* L. 'Russet Burbank' and 'Shepody'.
Key words: herbicide injury, potato injury, yellow nutsedge control.

Se llevaron al cabo estudios de campo en 2007 y 2008 cerca de Nyssa, OR y Pasco y Paterson, WA para evaluar el control de la *Cyperus esculentus* L. CYPES y malezas de hoja ancha y la tolerancia de la papa (*Solanum tuberosum* L) al imazosulfuron. La papa (*Solanum tuberosum* L.) no presentó daños debido al imazosulfuron mientras que en Washington, causó algo de clorosis en el follaje con variaciones que iban del 6 al 15% y de < 4% a los 6 y 15 días después de la POST aplicación, respectivamente. Las aplicaciones secuenciales de imazosulfuron controlaron la *Cyperus esculentus* L. CYPES mejor que una sola PRE aplicación. Las aplicaciones secuenciales de imazosulfuron individualmente o en combinación con S-metacloro controlaron la *Cyperus esculentus* L. CYPES en un > 92 y 89% a los 21 y 42 días después de las POST aplicaciones, respectivamente. El imazosulfuron controló en ≥ 98% la *Chenopodium album* L y en un 100% las especies de *Amaranthus* spp. El imazosulfuron proporcionó un control de la *Malva neglecta* Wallr a lo largo de la estación en Nyssa. Sin embargo, el imazosulfuron falló en el control de la *Salsola tragus* L en Paterson, y sólo controló parcialmente la *Solanum physalifolium* Rusby. En Niza el rendimiento de la variedad de papa más común en EE UU, varió de 44 a 54 T ha^{-1} y de 42 a 52 T ha^{-1} donde se utilizaron tratamientos PRE aplicados y secuenciales de imazosulfuron en 2007 y 2008, respectivamente. El rendimiento de la variedad de papa más común en EE UU al utilizar tratamientos PRE aplicados y secuenciales de imazosulfuron y tratamientos en Pasco promediaron de 49 y 57 T ha^{-1} en 2007 y en Paterson de 36 a 54 T ha^{-1} en 2008. Los rendimientos más bajos en 2008 se atribuyeron al deficiente control de la *Solanum physalifolium* Rusby. El imazosulfuron tiene potencial para ser una herramienta valiosa en el manejo de la *Cyperus esculentus* L. en el cultivo de la papa. Estudios futuros son necesarios para evaluar la persistencia en el suelo del imazosulfuron y poder establecer parámetros de seguridad en los cultivos sembrados en rotación con la papa.

Weed management is an essential component of potato production systems in the Pacific Northwest of the United States and other parts of the world. Weeds can reduce tuber yields through direct competition with the crop for light, moisture, nutrients, and may harbor insects and diseases that affect potatoes if they are not controlled in a timely manner (Boydston et al. 2008; Keeley and Thullen 1978). Herbicides and cultivation are utilized to manage weeds, especially in the early part of the growing season when newly emerged potato plants are vulnerable to weed competition. Methods for controlling yellow nutsedge are especially important for producers in the Pacific Northwest, where the weed is widely distributed. Control of yellow nutsedge has primarily been accomplished through the use of soil-active herbicides, which are applied before the weed emerges and competes with the potato crop.

In agricultural fields, nutsedge species reproduce and spread primarily through the production of underground tubers (Wills 1987). If not controlled, yellow nutsedge reduces potato tuber yield and produces a larger number of its own

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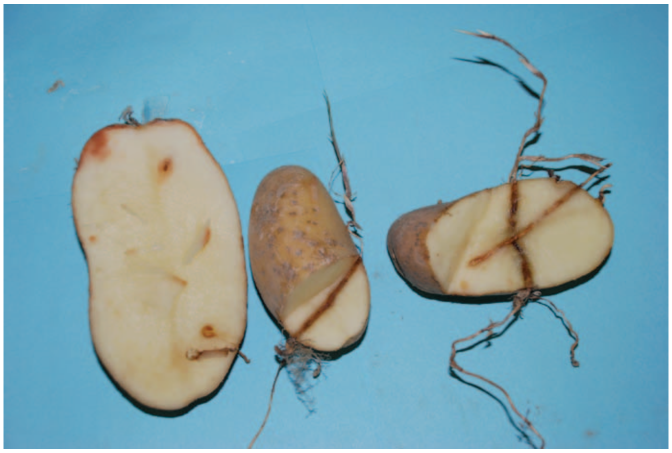

Figure 1. Yellow nutsedge rhizomes with tubers growing through a potato tuber at Nyssa, OR (Photo: courtesy of Dr. Joel Felix, Oregon State University/ Malheur Experiment Station, 2008).

tubers, which results in an increased population density and distribution in the field. In addition, Boldt (1976) found evidence that yellow nutsedge rhizomes can penetrate potato tubers and lower both yield and quality. It is not uncommon in production fields of eastern Oregon for yellow nutsedge rhizomes to grow through or deposit their tubers in potatoes (Figure 1) (J. Felix, personal observation). Webster and Coble (1997) concluded that nutsedge species were among the most troublesome weeds in all crops in the United States because they are well established and relatively difficult to control. Several sulfonylurea herbicides, including rimsulfuron and halosulfuron have been tested for yellow nutsedge control and/or potato tolerance, but excessive potato injury or lack of season long yellow nutsedge control have limited their use or registration in potato (Ackley et al. 1996; Boydston 2007; Grichar et al. 2003; Wilson et al. 2001). Currently, chemical weed control programs targeting yellow nutsedge in potato include different combinations of *s*-metolachlor, dimethenamid-p, EPTC, rimsulfuron, and metribuzin (Ackley et al. 1996; Bailey et al. 2001; Boydston et al. 2008; Richardson et al. 2004). Ackley (1996) reported control of yellow nutsedge with rimsulfuron at 35 g ha^{-1} was inconsistent, ranging from 51 to 89% when grown in absence of a crop.

The herbicide imazosulfuron (coded V-10142) is being developed and tested by Valent® USA for possible registration and use on several solanaceous crops including potato. Imazosulfuron is a member of the sulfonylurea herbicide family; these herbicides control weeds at low application rates and have high selectivity and low mammalian toxicity (Hay 1990; Morrica et al. 2001). Properties of imazosulfuron include a molecular weight of 412.8, a p*K*a of 4, octanol-water partition coefficient (*K*ow) of 1.12 (pH 7, 25 C), and its solubility in water is 0.308 g L^{-1} (pH 7 and 25 C). Imazosulfuron is currently registered for control of many annual and perennial broadleaf weeds and sedges in paddy rice (75–95 g ai ha^{-1}) and turf (500–1,000 g ai ha^{-1}) (Tomlin 1997). Morrica et al. (2001) reported that once applied to the soil, imazosulfuron degrades aerobically to 2-chloroimidazo[1,2-α]pyridine-3-sulfonamide and 1-(2-chloroimidazol[1,2-α]pyridine-3-ylsulfonyl)-3-(4-hydroxy-6-methoxypyrimidin-2-yl)urea; whereas anaerobic conditions produce 2-amino-4,6-dimethoxypyrimidine, suggesting that degradation was due to microorganisms, which have the ability to demethylate imazosulfuron. In aerobic and anaerobic conditions, imazosulfuron dissipated from the soil with a half-life of approximately 70 and 4 d, respectively. Imazosulfuron does not require mechanical incorporation into the soil when applied pre-emergence. The objective of this study was to determine the most effective rates for yellow nutsedge and broadleaf weed control, timings, and phytotoxicity of imazosulfuron when applied alone and in combination with other herbicides used in potato production.

Table 1. Soil properties for imazosulfuron study sites at Nyssa, OR, Pasco and Paterson, WA 2007 and 2008.

	Nyssa, OR		Pasco, WA	Paterson, WA
	2007	2008	2007	2008
Soil type	Nyssa silt loam[a]	Fine sandy loam[b]	Fine sandy loam[c]	Quincy sand[d]
pH	7.8	7.9	6.7	7.0
Organic matter (%)	1.5	1.28	0.64	0.4
Soil texture				
Sand (%)	15	58	69	95
Silt (%)	67	24	6	2
Clay (%)	18	18	25	3

[a] Moderately deep, well drained (coarse–silty, mixed, superactive, mesic Xeric Haplodurids).

[b] Deep, well drained (Turbyfill fine sandy loam, coarse–loamy, mixed, superactive, calcareous, mesic Xeric Torriorthents).

[c] Neppel fine sandy loam (coarse–loamy over sand or sandy–skeletal, mixed, superactive, mesic, Durinodic Xeric Haplocambids).

[d] Quincy sand (mixed, mesic Xeric Torripsamments).

Materials and Methods

Field studies were conducted in 2007 and 2008 near Nyssa, OR and Pasco and Paterson, WA to evaluate yellow nutsedge control and potato tolerance to imazosulfuron. Descriptions for soil type and properties at each site are presented in Table 1. The study sites were naturally infested with yellow nutsedge except for the 2008 site at Paterson, which was largely free of yellow nutsedge. Study sites in 2007 had very few broadleaf weeds, and yellow nutsedge was the most prominent (85% of the population). Broadleaf weed species present at Nyssa in 2008 included common lambsquarters, redroot pigweed (*Amaranthus retroflexus* L.) and Powell amaranth (*Amaranthus powellii* S. Wats.) and common mallow at 15, 10, and 5%, respectively. The Paterson site was infested with hairy nightshade, common lambsquarters, and Russian thistle at 65, 30, and 5%, respectively.

Primary tillage was completed by the cooperating grower at the respective sites following local recommendations for potato production. Similarly, fertilization, other pest control, and irrigation were carried out by the growers following common production practices. Potato varieties ‘Russet Burbank’ and ‘Shepody’ were planted on April 6 and March

20, 2007 at seed piece spacing of 22.5 cm in rows spaced at 91 and 86 cm apart, at Nyssa and Pasco, respectively. The same spacing was used in 2008 to plant 'Ranger Russet' potato variety on April 4 and March 19 at Nyssa and Paterson, respectively. Potato rows were harrowed and rehilled (standard grower practice in Pacific Northwest) just prior to potato emergence. Experiments were established in a randomized complete block design with four replications. Plots were 2.7 m wide by 9.1 m long and 2.6 m wide by 11 m long at Nyssa and Washington sites, respectively. Imazosulfuron rates evaluated were 336, 450, 560 g ai ha^{-1} applied pre-emergence (PRE) to both yellow nutsedge and potato; sequential treatments were applied at 336, 450, and 560 g ai ha^{-1} PRE and postemergence (POST). Other treatments were tank mixtures of imazosulfuron plus *s*-metolachlor applied at 340 plus 1,060 g ai ha^{-1} (PRE) followed by imazosulfuron at 450 g ai ha^{-1} POST, rimsulfuron plus *s*-metolachlor applied at 17.5 plus 1,060 g ha^{-1} PRE followed by rimsulfuron at 17.5 g ai ha^{-1} POST, *s*-metolachlor plus metribuzin applied at 1,060 plus 213 g ai ha^{-1} PRE followed by imazosulfuron at 450 g ai ha^{-1} POST, *s*-metolachlor plus metribuzin applied at 1,060 plus 213 g ai ha^{-1} PRE followed by rimsulfuron at 17.5 g ai ha^{-1} POST. The study also included an industry/grower standard, which was a tank mixture of EPTC plus pendimethalin plus metolachlor at 4,400 plus 840 plus 1,060 g ai ha^{-1} PRE at Nyssa and flumioxazin plus pendimethalin plus metribuzin at 52.7 plus 840 plus 213 g ai ha^{-1} in Washington trials. The industry/grower standard treatment was also hand weeded at all sites and served as a weed-free control. All POST application timings included methylated seed oil (MSO) at 1% (V/V) spray solution. An untreated control was also included at each site.

Herbicides were applied in a total spray volume of 187 L ha^{-1} on April 30 and May 24, 2007 and May 15 and June 7, 2008 for PRE and POST, respectively, at Nyssa. The corresponding dates at the Pasco site were April 11 and May 4, 2007 and at the Paterson site were April 22 and May 12, 2008 for PRE and POST, respectively. Herbicides were applied with a backpack CO_2 sprayer[1] equipped with six TeeJet 8002 EVS and 8002 XR flat fan nozzles[2] operated at 241 and 186 kPa at Nyssa and Washington sites, respectively. All POST herbicide treatments were applied when potato sprouts averaged 15 cm tall and yellow nutsedge was at 5 to 15 cm height.

Potato injury and yellow nutsedge control were visually assessed on a scale of 0 to 100% (where 0 = no injury/no weed control and 100% = crop death/complete weed control) at 7, 14, 21, and 42 d after treatment (DAT) each year. The same scale was used to evaluate potato row closure at 40 d after emergence visually. Potato yield was determined on October 5 and July 9, 2007 at Nyssa and Pasco and September 15 and 8, 2008 at Nyssa and Paterson, respectively, by weighing tubers harvested with the use of a mechanical harvester from 6 m of the center row. 'Shepody', which was used at Pasco in 2007, is an early maturity variety grown for a shorter season than 'Ranger Russet'. Tubers from each plot were subsequently graded by size and quality according to U.S. Department of Agriculture grading standards (Anonymous 1991). Nontransformed data were subjected to ANOVA with the use of PROC GLM procedure in SAS.[3] Type III statistics were used to test for significant differences ($P < 0.05$) of years, treatments, sites, and their interactions with visual plant injury, yellow nutsedge control, and potato yield variables. ANOVA of visual estimates of plant injury and yellow nutsedge control was subjected to a normality test. Because analysis of square-root-transformed data did not change the results of ANOVA, the nontransformed data were used in the final analysis. Data were pooled across sites when no significant sites, year-by-site, or year-by-treatment interactions were detected. Mean separations were performed with the use of Fisher's protected LSD test at $\alpha = 0.05$.

Table 2. Yellow nutsedge control in potato 21 d after treatment with imazosulfuron and imazosulfuron tank mixes near Nyssa, OR and Pasco, WA in 2007 and 2008.

Treatment		Timing	Yellow nutsedge control 21 DAT: Nyssa 2007	Nyssa 2008	Pasco[a] 2007
	g ai ha^{-1}		%		
Imazosulfuron	336	PRE	55	97	90
	450	PRE	75	98	80
	560	PRE	83	99	90
	336, 336	PRE; POST[b]	89	99	100
	450, 450	PRE; POST	89	99	100
	560, 560	PRE; POST	95	99	100
Imazosulfuron	336	PRE	95	99	100
s-metolachlor	1,060	PRE			
Imazosulfuron	450	POST			
s-metolachlor	1,060	PRE	94	99	100
Metribuzin	213	PRE			
Imazosulfuron	450	POST			
Rimsulfuron	17.5	PRE	88	99	90
s-metolachlor	1,060	PRE			
Rimsulfuron	17.5	POST			
s-metolachlor	1,060	PRE	95	99	87
Metribuzin	213	PRE			
Rimsulfuron	17.5	POST			
Grower standard[c]			95	99	100
Untreated control			0	0	0
LSD P = 0.05			10	2	11

[a] The 2008 trial at Paterson was conducted in a field free of yellow nutsedge.

[b] All POST treatments included methylated seed oil at 1% V/V spray solution, applied on May 24, 2007 and June 7, 2008 at Nyssa and on May 4, 2007 and May 12, 2008 at Pasco and Paterson, respectively.

[c] Grower standard treatments were tank mixes of EPTC plus pendimethalin plus metolachlor at 4,400 plus 840 plus 1,060 g ai ha^{-1} PRE at Nyssa, OR. and flumioxazin plus pendimethalin plus metribuzin at 52.7 plus 840 plus 213 g ai ha^{-1} plus hand weeding at Pasco, WA.

Results and Discussion

Yellow Nutsedge Control. There was a site-by-year-by-treatment interaction for yellow nutsedge control at 21 and 42 DAT (Tables 2 and 3). Analysis-of-variance results for evaluations at 7 and 14 DAT were similar to 21 DAT, and therefore only the 21- and 42-DAT data are presented. Yellow nutsedge control at 21 DAT was lowest when imazosulfuron was applied PRE at 336 and 450 g ai ha^{-1} (Table 2) at Nyssa

Table 3. Yellow nutsedge control in potato 42 d after treatment (DAT) with imazosulfuron and imazosulfuron tank mixes and percent potato row closure near Nyssa, OR, Pasco, WA, and Paterson, WA in 2007 and 2008.

Treatment		Timing	Yellow nutsedge control		Potato row closure	
			42 DAT		40 d after emergence	
			2007	2008	Nyssa	Pasco/ Paterson
	g ai ha^{-1}		%			
Imazosulfuron	336	PRE	68	79	97	86
	450	PRE	79	89	97	90
	560	PRE	84	96	97	83
	336, 336	PRE, POST[a]	92	96	96	83
	450, 450	PRE, POST	94	94	97	84
	560, 560	PRE, POST	96	99	96	83
Imazosulfuron	336	PRE	94	97	96	84
s-metolachlor	1,060	PRE				
Imazosulfuron	450	POST				
s-metolachlor	1,060	PRE	96	99	97	86
Metribuzin	213	PRE				
Imazosulfuron	450	POST				
Rimsulfuron	17.5	PRE	87	99	96	84
s-metolachlor	1,060	PRE				
Rimsulfuron	17.5	POST				
s-metolachlor	1,060	PRE				
Rimsulfuron	17.5	PRE	91	98	98	90
Metribuzin	213	POST				
Grower standard[b]			98	99	97	90
Untreated control			0	0	94	91
LSD P = 0.05			3	4	2	5

[a] All POST treatments included methylated seed oil at 1% V/V spray solution, applied on May 24, 2007 and June 7, 2008 at Nyssa, and on May 12, 2008 at Pasco and Paterson, respectively.

[b] Grower standard treatments were tank mixes of EPTC plus pendimethalin plus metolachlor at 4,400 plus 840 plus 1,060 g ai ha^{-1} PRE at Nyssa, OR and flumioxazin plus pendimethalin plus metribuzin at 52.7 plus 840 plus 213 g ai ha^{-1} plus hand weeding at Paterson, WA.

in 2007. However, sequential applications of imazosulfuron controlled yellow nutsedge significantly better, and similar to control achieved with tank-mix combinations with other herbicides (Table 2). In 2008, yellow nutsedge control was comparatively better and PRE application timing controlled yellow nutsedge similar to sequential and tank-mix combination treatments. The difference in yellow nutsedge control between years may be attributed to the timing of the first irrigation in relation to herbicide application. The first irrigation was delivered 3 d after herbicide application in 2008, while in 2007 there was a lag of 7 d between herbicide application and irrigation. This observation is consistent with results reported by Morrica et al. (2001), indicating the need for herbicide activation with water shortly after application. Delayed irrigation at Nyssa in 2007 may have allowed yellow nutsedge to continue to emerge and grow prior to the herbicide being activated with irrigation water. However, differences in soil type at Nyssa in 2007 and 2008 may have contributed to the observed variations in yellow nutsedge control. Heavier texture soil (silt loam) at Nyssa in 2007 may have required higher rates of imazosulfuron in order to express optimum herbicidal activity.

Yellow nutsedge control at Pasco was markedly better in 2007 compared to that observed at the Nyssa site (Table 2). Yellow nutsedge control with imazosulfuron PRE application timing ranged from 80 to 90% and was similar to the control provided by a tank-mix combination of rimsulfuron plus *s*-metolachlor (17.5 plus 1,060 g ai ha^{-1}) PRE followed by rimsulfuron (17.5 g ai ha^{-1}) POST. Additionally, imazosulfuron PRE control of yellow nutsedge was similar to that obtained with sequential applications of *s*-metolachlor plus metribuzin (1,060 plus 213 g ai ha^{-1}) PRE followed by rimsulfuron (17.5 g ai ha^{-1}) POST. Sequential applications of imazosulfuron controlled yellow nutsedge similar to that with combination treatments, which ranged between 90 and 100%. The high level of yellow nutsedge control at Pasco in 2007 was likely a result of a timely irrigation (within 24 h) following the PRE herbicide applications and relatively low densities of yellow nutsedge, ranging from 1 to 10 plants m^2. The 2008 study at Paterson was in a field free of yellow nutsedge, so no control ratings were quantified.

Evaluations at 42 DAT indicated reduced yellow nutsedge control with imazosulfuron PRE treatments in 2007 across sites, which ranged from 68 to 84% (Table 3). Imazosulfuron sequential treatments controlled yellow nutsedge similar to tank-mix combination treatments, ranging between 91 and 98%. In 2008, imazosulfuron at 336 g ai ha^{-1} PRE controlled yellow nutsedge significantly lower than other treatments. Yellow nutsedge control ranged from 89 to 99% with all other treatments compared to 79% for imazosulfuron 336 g ha^{-1} PRE alone. Again, the difference in yellow nutsedge control between years could mainly be attributed to timing of the first irrigation after herbicide application. It appears that delivery of irrigation water within 3 d of imazosulfuron PRE application is crucial in order to activate the herbicide and provide optimum yellow nutsedge control.

Annual Broadleaf Weed Control. Common lambsquarters, *Amaranthus* spp., and common mallow were the most prevalent broadleaf weeds at the Nyssa site. There was a site-by-treatment interaction for broadleaf weed control, so efficacy data are presented separately for each site-year (Table 4). Imazosulfuron controlled 100% of common lambsquarters and pigweed species at 36 DAT at Nyssa regardless of herbicide application timing (Table 4). Control of common mallow, a difficult-to-control weed in many cropping systems, ranged from 94 to 100%.

Common lambsquarters control ranged from 98 to 100% at the Paterson site, indicating no significant difference among herbicide treatments and application timing. However, control of hairy nightshade was poor when imazosulfuron was applied alone PRE, and ranged from 55 to 79% with application rates of 336 to 560 g ai ha^{-1}. Hairy nightshade control was improved with sequential applications of imazosulfuron, and ranged from 85 to 92% for PRE plus POST treatments (Table 4). Imazosulfuron plus *s*-metolachlor applied at 336 plus 1,060 g ai ha^{-1}, respectively, PRE followed by POST imazosulfuron at 450 g ai ha^{-1} controlled all weeds well with the exception of Russian thistle (Table 4). Imazosulfuron did not control Russian thistle when applied PRE or POST. All treatments containing metribuzin controlled Russian thistle at a level of 95% or greater (Table 4).

Table 4. Common lambsquarters, redroot pigweed, common mallow, hairy nightshade, and Russian thistle control after treatment with imazosulfuron and imazosulfuron tank mixes near Nyssa, OR and Paterson, WA in 2007 and 2008.

			Nyssa (2007 and 2008)			Paterson (2008)		
			CHEAL[a]	AMARE	MALNE	CHEAL	SOLSA	SASKR
Treatment		Timing	36 d after PRE			35 d after PRE		
	g ai ha^{-1}		%					
Imazosulfuron	336	PRE	100	100	94	98	55	0
	450	PRE	100	100	94	100	75	0
	560	PRE	100	100	100	100	79	0
	336, 336	PRE, POST[b]	100	100	100	100	85	5
	450, 450	PRE, POST	100	100	100	100	90	3
	560, 560	PRE, POST	100	100	100	100	92	14
Imazosulfuron	336	PRE	100	100	100	100	98	6
s-metolachlor	1,060	PRE						
Imazosulfuron	450	POST						
s-metolachlor	1,060	PRE	100	100	100	100	99	100
Metribuzin	213	PRE						
Imazosulfuron	450	POST						
Rimsulfuron	17.5	PRE	100	100	100	100	100	66
s-metolachlor	1,060	PRE						
Rimsulfuron	17.5	POST						
s-metolachlor	1,060	PRE						
Rimsulfuron	17.5	PRE	100	100	100	100	100	95
Metribuzin	213	POST						
Grower standard[c]			100	100	100	100	100	100
Untreated control			0	0	0	0	0	0
LSD P = 0.05			NS[d]	NS	1.5	NS	13	17

[a] CHEAL = *Chenopodium album* (common lambsquarters), AMAXX = *Amaranthus retroflexus* (redroot pigweed), and *Amaranthus powelli* (Powell amaranth), MALNE = *Malva neglecta* (common mallow), SOLSA = *Solanum physalifolium* Rusby (hairy nightshade), SASKR = *Salsola tragus* L. (Russian thistle).

[b] All POST treatments included methylated seed oil at 1% V/V spray solution, applied on May 24, 2007 and June 7, 2008 at Nyssa, and on May 12, 2008 at Paterson.

[c] Grower standard treatments were tank mixes of EPTC plus pendimethalin plus metolachlor at 4,400 plus 840 plus 1,060 g ai ha^{-1} PRE at Nyssa, OR and flumioxazin plus pendimethalin plus metribuzin at 52.7 plus 840 plus 213 g ai ha^{-1} plus hand weeding at Paterson, WA.

[d] NS = no significant difference at the < 0.05 probability level.

Potato Response and Tuber Yield. Use of imazosulfuron did not affect time to potato row closure at Nyssa, which ranged from 96 to 98% at 40 d after emergence (Table 3). There was no detectable crop injury at Nyssa resulting from any of the imazosulfuron treatments. Slight chlorosis was observed on potato foliage following imazosulfuron treatments at Pasco and Paterson. Potato injury was ≤ 15% at 14 DAT and potatoes grew normally thereafter (data not shown). Potato row closure was slightly delayed at Pasco and Paterson when imazosulfuron was applied PRE at 560 g ai ha^{-1} compared to *s*-metolachlor plus rimsulfuron plus metribuzin at 1,060 plus 17.5 plus 213 g ai ha^{-1} and the industry/grower standard (Table 3). Potato row closure 40 days after emergence was 83 to 86% compared to 90% for potatoes treated with industry/grower standard herbicides.

There was a site-by-year interaction for potato yield, and therefore yield results are presented separately for each site, year, and herbicide treatments (Table 5). There was no significant difference among herbicide treatments for the < 113–g potato category at Nyssa and Pasco in 2007. The < 113–g potato yield category ranged from 7 to 9 T ha^{-1} at Nyssa and 5 to 9 T ha^{-1} at Pasco. The reduction in U.S. no. 1 tuber yield at Nyssa in 2007 when imazosulfuron was applied PRE was similar to the untreated control. The reduction in U.S. no.1 tubers at Nyssa was not a result of herbicide injury, but rather from increased competition with uncontrolled yellow nutsedge (Tables 2 and 3). The U.S. no. 1 yield ranged from 44 to 54 T ha^{-1} for the imazosulfuron PRE and sequential treatments, and 51 to 58 T ha^{-1} for the tank-mixture combination treatments, some of which included imazosulfuron (Table 5).

The U.S. no. 1 tuber yield at Pasco in 2007 ranged from 51 to 57 T ha^{-1} for herbicide treatments and averaged 48 T ha^{-1} for the untreated control (Table 5). Total tuber yield at Nyssa in 2007 ranged from 62 to 78 T ha^{-1}. There was no significant difference among treatments for total tuber yield at Pasco in 2007, which ranged from 58 to 64 T ha^{-1}. Total tuber yield results in 2007 were a direct reflection of the level of yellow nutsedge and broadleaf weed control at each site.

Potato yield in 2008 for the < 113–g category at Nyssa was similar across herbicide treatments and ranged from 5 to 9 T ha^{-1} and highest in the untreated control at 15 T ha^{-1}. The U.S. no. 1 potato yield ranged from 42 to 50, and was markedly lower for the untreated control (32 T ha^{-1}), which was heavily infested with yellow nutsedge and broadleaf weeds. Visual inspection at harvest showed yellow nutsedge rhizomes and tubers growing through potato tubers in the untreated plots (Figure 1). There was no difference among treatments for total tuber yield at Nyssa in 2008, which ranged from 59 to 66 T ha^{-1} (Table 5).

Total tuber yield at Paterson in 2008 when imazosulfuron was used PRE at 560 g ha^{-1} was only 40 T ha^{-1} and similar

Table 5. Potato yield after imazosulfuron and imazosulfuron applied PRE alone and POST in combination with other herbicides near Nyssa, OR, Pasco, WA, and Paterson, WA in 2007 and 2008.

			Potato tuber yield											
			Nyssa 2007			Nyssa 2008			Pasco 2007			Paterson 2008		
Treatment		Timing	< 113 g	U.S. no. 1[a]	Total	< 113 g	U.S. no. 1	Total	< 113 g	U.S. no. 1	Total	< 113g	U.S. no. 1	Total
	g ai ha^{-1}		MT ha^{-1}											
Imazosulfuron	336	PRE	6	46	62	6	42	59	7	52	59	5	36	42
	450	PRE	5	46	69	5	47	60	6	51	58	5	37	44
	560	PRE	9	44	68	5	52	64	6	52	60	5	37	40
	336, 336	PRE; POST[b]	6	50	70	7	50	65	5	49	56	3	41	48
	450, 450	PRE, POST	8	49	70	7	49	64	7	57	64	3	47	53
	560, 560	PRE, POST	6	54	80	5	44	58	5	57	64	4	54	61
Imazosulfuron	336	PRE												
s-metolachlor	1,060	PRE	7	53	69	87	47	66	6	55	62	3	47	55
Imazosulfuron	450	POST												
s-metolachlor	1,060	PRE	6	54	69	7	48	62	5	52	59	3	49	56
Metribuzin	213	PRE												
Imazosulfuron	450	POST												
Rimsulfuron	17.5	PRE												
s-metolachlor	1,060	PRE	8	58	78	7	48	64	6	57	63	3	56	63
Rimsulfuron	17.5	POST												
s-metolachlor	1060	PRE												
Rimsulfuron	17.5	PRE	8	59	75	5	46	58	8	51	60	3	59	64
Metribuzin	213	POST												
Grower standard[c]			6	51	72	6	47	59	9	51	60	6	52	58
Untreated control			6	45	58	159	32	57	7	48	58	7	24	31
LSD P = 0.05			NS[d]	7	9	3	9	NS	NS	4	NS	3	14	13

[a] U.S. no. 1 tubers have no defects and weigh ≥ 113 g each.

[b] All POST treatments included methylated seed oil at 1% V/V spray solution, applied on May 24, 2007 and June 7, 2008 at Nyssa, and on May 4, 2007 and May 12, 2008 at Pasco and Paterson, respectively.

[c] Grower standard treatments were tank mixes of EPTC plus pendimethalin plus metolachlor at 4,400 plus 840 plus 1,060 g ai ha^{-1} PRE at Nyssa, OR and flumioxazin plus pendimethalin plus metribuzin at 52.7 plus 840 plus 213 g ai ha^{-1} plus hand weeding at Pasco and Paterson, WA.

[d] NS = no significant difference at the < 0.05 probability level.

to the untreated control, which averaged 31 T ha^{-1} (Table 5). Generally, total yield was relatively lower for imazosulfuron PRE application timing compared to other treatments and could be attributed to poor hairy nightshade and Russian thistle control with these treatments (Table 4). The U.S. no. 1 tuber yield at Paterson following sequential applications of imazosulfuron or other herbicide tank mixtures ranged from 41 to 59 T ha^{-1} and reflected the level of hairy nightshade control with various treatments.

In this study, imazosulfuron controlled yellow nutsedge and broadleaf weeds, with the exceptions of hairy nightshade and Russian thistle, similar to or greater than herbicides already registered for use in potato (Ackley et al. 1996; Boydston et al. 2008; Richardson et al. 2004). No herbicide injury symptoms were evident on potato tubers for any of the herbicide treatments whether applied PRE or POST, sequential, or in combination with other herbicides. The results also indicated that imazosulfuron activation by irrigation water within 3 d of herbicide application is crucial for effective yellow nutsedge control. Based on these findings, imazosulfuron appears to be safe for use on potato and a promising tool for yellow nutsedge management in potato-based cropping systems. However, rotational studies are needed to evaluate the soil persistence for imazosulfuron in order to determine the safety to crops grown in rotation with potato. The high level of yellow nutsedge control provided by imazosulfuron in potato suggests a potential to reduce nutsedge buildup when rotational cereal crops such as wheat are grown after potato.

Sources of Materials

[1] CO_2 Sprayers Systems, Bellspray Inc., R&D Sprayers, P. O. Box 267, Opelousas, LA 70571.

[2] TeeJet 8002 EVS and 8002 XR flat-fan nozzle tips, Spraying Systems Co., P. O. Box 7900, Wheaton, IL 60188.

[3] PROC GLM, Statistical Analysis Systems (SAS) software, Version 9.2. Statistical Analysis Systems Institute, Inc., P.O. Box 8000, Cary, NC 25712-8000.

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Literature Cited

Ackely, J. A., H. P. Wilson, and T. E. Hines. 1996. Yellow nutsedge (*Cyperus esculentis*) control POST with acetolactate synthase-inhibiting herbicides. Weed Technol. 10:576–580.

Anonymous. 1991. United States Standards for grades of potatoes. USDA Agricultural marketing service. 10 p.

Bailey, A. W., H. P. Wilson, and T. E. Hines. 2001. Influence of cultivation and herbicide programs on weed control and net returns in potato (*Solanum tuberosum*). Weed Technol. 15:654–659.

Boldt, P. F. 1976. Factors influencing the selectivity of U-compounds on yellow nutsedge. M.S. thesis. Ithaca, NY: Cornell University.

Boydston, R. A. 2007. Potato and weed response to postemergence-applied halosulfuron, rimsulfuron, and EPTC. Weed Technol. 21:465–469.

Boydston, R. A., P.J.S. Hutchinson, and R. Bellinder. 2008. Weed management. Pages 223–233 *in* D. Johnson, ed. Potato Health Management. Boydston, MN: APS Press.

Grichar, W. J., B. A. Besler, and K. D. Brewer. 2003. Purple nutsedge control and potato (*Solanum tuberosum*) tolerance to sulfentrazone and halosulfuron. Weed Technol. 17:485–490.

Hay, J. V. 1990. Chemistry of sulfonylurea herbicides. Pestic. Sci. 29:247–261.

Keeley, P. E. and R. J. Thullen. 1978. Light requirements of yellow nutsedge (*Cyperus esculentus*) and light interception by crops. Weed Sci. 26:10–16.

Morrica, P., A. Giordano, S. Seccia, F. Ungaro, and M. Ventriglia. 2001. Degradation of imazosulfuron in soil. Pest Manag. Sci. 57:360–365.

Richardson, R. J., C. M. Whaley, H. P. Wilson, and T. E. Hines. 2004. Weed control and potato (*Solanum tuberosum*) tolerance with dimethenamid isomers and other herbicides. Am. J. Potato Res. 81:299–304.

Tomlin, C.D.C. 1997. The Pesticide Manual. 11th edition. Farnham, Surrey, UK: BCPC. Pp. 703–704.

Webster, T. M. and H. D. Coble. 1997. Changes in the weed species composition of the southern United States: 1974 to 1995. Weed Technol. 11:308–317.

Wills, G. D. 1987. Description of purple and yellow nutsedge (*Cyperus rotundus* and *Cyperus esculentus*). Weed Technol. 1:2–9.

Wilson, H. P., D. W. Monks, T. E. Hines, and R. J. Mills. 2001. Responses of potato (*Solanum tuberosum*), tomato (*Lycopersicon esculentum*), and several weeds to ASC-67040 herbicide. Weed Technol. 15:271–276.

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